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THE BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

(INCORPORATED)

The Prevention of Trouble due to Aquatic Growths in Condenser Systems, with Special Reference to the Destruction of Mussels.

Critical Résumé by

D. V. ONSLOW, A.M.I.E.E.

BUREAU OF HYGIENE & TROPICAL DISEASES
20 MAR. 1931

LONDON
36 AND 38 KINGSWAY, W.C.2
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The Prevention of Trouble due to Aquatic Growths in Condenser Systems, with Special Reference to the Destruction of Mussels.

Introduction

IT has been reported that trouble is frequently caused in condenser systems by the accumulation of mussels and other organic growths which manifest themselves in the conduits leading to the condenser or in the condenser tubes themselves. In this connection the Association has been approached by certain of its members for information as to methods of preventing the trouble. A questionnaire was sent to manufacturers of condensers and to certain large users who were known to have experienced trouble from these causes. The present report is based on the replies received, which indicate that the use of chlorine is the most satisfactory method of preventing trouble due to the above causes.

Importance of High Vacuum

It is well known that the maintenance of a high vacuum in the power plant is of very great importance, since a loss of 1 in. in the vacuum increases the steam consumption, and therefore the fuel bill, by about 5 per cent. With good plant a high vacuum can be maintained only if the water-side cooling surfaces of the surface condenser tubes are kept clean, and even a slight film of mud adhering to the tubes will have a detrimental effect upon the vacuum.

Growth of Organisms

Practically all waters drawn from canals, rivers, ponds, and the sea, contain organisms which, under favourable conditions of temperature and food supply in the condenser, multiply rapidly and form a glutinous coating upon which the inorganic suspended solids carried in the water collect, forming in due time a coating of low heat conductivity which reduces the efficiency of the condenser. Spawn of algæ will in some cases form a coating on the tubes ¼ in

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thick in 48 hours, if no preventative measures are taken. When condensing with sea-water, mussels and limpets grow on the internal surface of the conduits and pipes, reducing the flow capacity of the suction pipes and increasing the cost of pumping. In one case, for instance, the diameter of the suction piping was reduced from 24 in. to about 20 in. in six months due to crustacean growth.

The growth of the mussel would appear to vary in different localities, and is more rapid during the summer than during the winter. Whereas in some very favourable places the mussel may take only about 15 months to grow to a length of about 2 in., in other places it may take three years, and in unfavourable places even up to about 8 years. But from the point of view of trouble in condenser systems it is not the rate of individual growth, but of mass growth that is of importance, and a thick layer of small mussels will form in the course of a few months.

Location of Obstructions

The slime produced by algæ accumulates in the condenser tubes as well as in other parts of the system, but the experiences of various users would seem to indicate that mussels or mussel-spawn, while seldom found in the tubes, accumulate in various parts of the system. For instance, one firm stated that where they had had trouble it had been occasioned by mussels collecting and breeding in the warm regions of the system. They appeared instinctively to settle in the discharge pipes, and had seldom been found in the suction pipes or water boxes of the condensers. On examination of a long range of discharge pipes where mussels had found a lodgment it was observed that when water was not flowing they were arranged so that their longitudinal dimensions were directed radially towards the centre, but their connections were so flexible that when flow took place they could settle in the line of least resistance. I was also found that where several air-locks occurred in the range these points formed special breeding centres for the mussels, and when steps were taken to evacuate the air the mussels disappeared

On the other hand, many users of condensing plant have stated that they had trouble from mussels collecting in the suction pipe and inlet pipes, as well as in the discharge pipes and culverts.

Methods of Prevention

General.

Below are given some of the methods which are being employed to prevent the trouble due to fouling of condenser systems, some of which are more effective than others. Sulphuric acid has been tried for killing mussels, but it was found that it did not destroy them. The use of chlorine is the method most in use and appears to be the most satisfactory for both the prevention and destruction of aquatic growths and slimy matter in condenser tubes. It is understood that it is now being increasingly employed for preventing the growth of and for destroying mussels in the system with satisfactory results. The object of chlorination is not to sterilize the water completely, but to render the organisms incapable of attaching themselves to the surfaces of the plant and so prevent the building up of a coating. It is understood that the comparatively weak solution of chlorine employed has no corrosive effect on any parts of the condenser.

There does not appear to be much published literature on the prevention of mussel growth, but the following have been noted:—

(i) " Chemical Treatment of Condensing Water," by L. L. Robinson (Chief Engineer, Borough of Hackney Electricity Works). *Electrical Times*, June 22nd, 1922.

(ii) " Practical Biology, and Means of Destroying Migratory Mussel (*Dreissensia polymorpha*) in Waterworks." (*Wilhelmi, Deut. Wasserwirtschaft*, 1923, *18*, 107.)

(iii) " The Harmfulness of *Dreissensia polymorpha* to Water Plants." (*Rock, Gesundh. Ing.* 1925, *48*, 97.)

All the above papers indicate that the use of chlorine is the most effective and practical means of destruction of the mussel.

Some users who were not acquainted with any method of prevention, cleaned the tubes by manual labour, and where they have had bad trouble due to mussels they have been obliged to close down periodically, and after killing the shell-fish by poison, removed their remains by hand.

A high water velocity, say, above 6 feet per second, tends to keep down the growth of mussels as they appear to be unable to attach themselves, but once attached they can retain their position at considerably higher water velocities.

The Use of Chlorine.

The Paterson Engineering Co., Ltd., has specialized for many years in the sterilization of water for various purposes by gaseous chlorine, and manufacture different types of apparatus. The type usually employed for condenser treatment is called the " Manometer Chloronome." The chlorine is added in minute and accurately measured quantities by means of this apparatus. The process is continuous. Where bad fouling has already taken place, one part of chlorine to a million parts of circulating water may be required to kill the growths, but once this is effected, only about one-fifth part to a million is necessary to check the development of the organisms and to preserve the tubes in a permanently clean and efficient condition. It also destroys all forms of shell life, and by removing their means of sustenance prevents their growth.

The proportion of chlorine gas required is so minute that no corrosive effect is produced in the pipe lines and condenser tubes; the whole of this minute dose is absorbed immediately by the organic matter and by the destruction of the micro-organisms responsible for the initial trouble. The chlorine should be injected into the circulating water suction pipe as far from the condensers as possible, to enable it to mix thoroughly with the water before entering the condensers.

Experience With the Use of Chlorine.

Mr. L. L. Robinson (Chief Engineer of the Borough of Hackney Electricity Works) in an article in the *Electrical Times* (*loc. cit.*), has given his experience of the use of chlorinating plant in connection with a 6,000 kW condensing plant in which bad fouling was taking place. In the case of the untreated water, the cost of keeping the plant clean averaged £5 8s. 0d. per week, whereas with the use of a Chloronome the weekly cost was £2 9s. 0d., including capital charges. Moreover, since the chlorinating plant had been introduced a higher average vacuum was maintained, and the saving of fuel due to the better vacuum was £28 10s. 0d. per week (with coal at 23s. 3d per ton). Less circulating water was used, and therefore there was saving of energy used for pumping. Mr. L. L. Robinson gives urves showing load, river temperature, and vacuum, which clearly ndicate the great improvement effected by treating the condensing ater.

Mr. A. E. McKenzie (Chief Engineer of the Wimbledon Corporation Electricity Department) has informed the Association that he installed a chlorinating plant about six years ago with very satisfactory results, to replace the practice then being followed of brushing through the tubes of all the main condensers two or three times weekly due to the choking of the tubes and consequent lowering of the vacuum. It definitely stopped the breeding of algæ, and it has only been necessary to open out the condensers once every three or four months to clean the mud out of the tubes. The chlorinating plant has been responsible for a higher average vacuum on the turbines of at least 1 in. throughout the last six years.

In the case of the Bombay Electric Light Station, where the diameter of the suction piping was reduced from 24 in. to 20 in. in six months due to mussel growth (as mentioned above), the installation of a chlorinating plant quickly destroyed the shell-life and kept the suction and other piping clear of this growth.

It would appear that the cost of installing chlorinating plant is repaid in a short time by savings upon cleaning costs and fuel made possible by the higher efficiency of the power plant.

It is said that Paterson Chloronomes have been installed with satisfactory results in more than 60 generating stations in this country and abroad for the prevention of mussel and other aquatic growths. Among other places, it is used especially for the prevention of mussel growth at H.M. Dockyards at Devonport, Portsmouth, and Chatham, and at the Llanelly and District Electric Lighting Co.

Raising the Temperature of Circulating Water.

(i) Investigations into trouble due to mussel growth were made in 1920 by Dr. Ritchie for the City of Edinburgh Electricity Department, and it was found that, if mussels were subjected to a temperature above the normal for a period of time depending on the temperature, they did not recover.

As a result of this research work, the system now adopted at Portobello, with satisfactory results, is to curtail the circulating water through the condensers to such an extent that the outlet temperature is raised to 89° or 90° F., and maintained at this temperature for a period of 12 to 14 hours.

In the early stages of operating the plant, it was realized that certain portions of the pipe-work did not receive this treatment, as, for example, the pipe lines between the pumps and the condensers on the inlet to the latter. This difficulty was overcome by arranging the opening of the valves on the land shafts in such a way that a portion of the water was pumped a second time. This had the immediate effect of loosening a large quantity of mussel growth in these inlet pipes, which gave considerable trouble for several days, large quantities of shell being found in the water boxes of the condenser. It was noted that all the shells were empty, the fish having been washed away.

Each section of the piping is treated every three weeks from the beginning of April to the end of October, and the precaution is taken of sending a diver down two of the shafts each year to make certain that the amount of treatment is sufficient.

(ii) In other cases where animal growth had formed in the circulating water pipes, it was destroyed periodically by admitting steam to the circulating water in the condenser with the inlet sluice valve closed, then allowing the hot water to run back down the suction pipe. Other means have also been resorted to in order to heat the circulating water sufficiently to kill the growth.

The Use of Copper Sulphate.

Trouble was experienced due to mussel spawn growing in the salt water main from the river-side to the works of the Cargo Fleet Iron Co., Ltd. The method used here by the Chief Engineer (Mr. C. Cook) was to insert at different points in the pipe line double inch cocks, and doses of dissolved sulphate of copper crystals (about 1 pint to 10,000 of water) were given periodically. This had the effect of loosening the spawn in contact with the pipe.

After the pipe was cleaned, attention was turned to the prevention of the growth, and for this purpose at regular intervals the crystals of copper sulphate were placed in the salt water tank and so diffused through the system. No trouble has been experienced with mussel growth since the treatment was begun in 1913. We are informed that the sulphate of copper, if used in the dilution stated, is not detrimental to any metals, and can be used with safety in pumps, pipes, etc.

A few years ago this remedy was recommended to a large firm which had been under the necessity of installing a new 30-in. main, a thousand yards long, to duplicate the main that was being choked with mussels, and at the first cleaning out they obtained about three truck loads.

Another user introduces copper sulphate at the river pumps. This loosens a good many mussels, which are caught in the screens near their power house, one mile away.

Sources of Information

In addition to the sources of information mentioned in the report, the following have also furnished information:—

Belliss and Morcom, Ltd.
Brush Electrical Engineering Co., Ltd.
Department of Scientific and Industrial Research.
Hick, Hargreaves & Co., Ltd.
Metropolitan-Vickers Electrical Co., Ltd.
Mirrlees, Watson Co., Ltd.
C. A. Parsons & Co., Ltd.
Richardsons, Westgarth & Co., Ltd.
Worthington-Simpson, Ltd.
Electricity Department, Brighton.
Electricity Department, Dundee.
Electricity Department, Plymouth.
Electricity Department, Portsmouth.
Electricity Department, Southampton.

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